EXHIBIT 1

KIRK-OTHMER

ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY

FOURTH EDITION

VOLUME **10**

EXPLOSIVES AND PROPELLANTS
TO
FLAME RETARDANTS FOR TEXTILES

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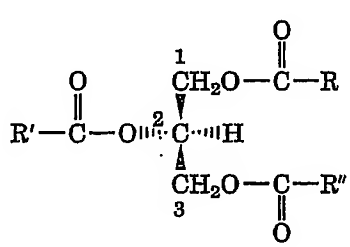
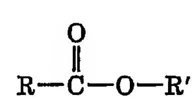
FATS AND FATTY OILS

Fats and oils are one of the oldest classes of chemical compounds used by humans. Animal fats were prized for edibility, candles, lamp oils, and conversion to soap. Fats and oils are composed primarily of triglycerides (**1**), esters of glycerol and fatty acids. However, some oils such as sperm whale (1), jojoba (2), and orange roughy (3) are largely composed of wax esters (**2**). Waxes (qv) are esters of fatty acids with long-chain aliphatic alcohols, sterols, tocopherols, or similar materials.



(**1**)



(**2**)

Fatty acids derived from animal and vegetable sources generally contain an even number of carbon atoms since they are biochemically derived by condensation of two carbon units through acetyl or malonyl coenzyme *A*. However, odd-numbered and branched fatty acid chains are observed in small concentrations in natural triglycerides, particularly ruminant animal fats through propionyl and methylmalonyl coenzyme *A*, respectively. The glycerol backbone is derived by biospecific reduction of dihydroxyacetone.

Structure (**1**) shows the stereochemistry of the triglyceride molecule. Positions are numbered by the stereochemical numbering (sn) system. In chemical processes the 1 and 3 positions are not distinguishable. However, for biological systems, the enantiomeric (*R* or *S*) form is important. Simple triglycerides contain only one type of fatty acid, eg, tristearin [*555-43-1*], and since the fatty acid residues in the 1 and 3 position are identical, do not exhibit enantiomeric forms. If more than one fatty acid is present, mixed triglycerides are distinguished. Naming mixed triglycerides without regard to stereochemistry involves two conventions: (*1*) the fatty acid with the shortest carbon chain is named first, eg, palmitodistearin, and (*2*) for fatty acids with an equal number of carbon atoms, the acid with the lesser number of double bonds is named first, eg, stearodiolein. When stereochemistry is taken into account, the acids are numbered as they occur, eg, *sn*-1-oleo-2-palmito-3-stearin.

Fatty acids may be saturated, monounsaturated, or polyunsaturated according to the number of double bonds in the alkyl chain. Naturally occurring double bonds are almost exclusively *cis* (*Z*) in configuration. Table 1 lists the fatty acids found in representative triglycerides. Fatty acids are often referred to by their common names (see CARBOXYLIC ACIDS). For example, 9-*cis*-octadecenoic acid has long been known as oleic acid. A convenient shorthand notation for fatty acids identifies the chain length followed by a colon and the number of double bonds in the chain, eg, oleic acid is 18:1. The most common fatty acids in animal and vegetable fats and oils are dodecanoic (lauric, 12:0), hexadecanoic (palmitic, 16:0), octadecanoic (stearic, 18:0), 9-*cis*-octadecenoic (oleic, 18:1), 9-*cis*,12-*cis*-octadecadienoic acid (linoleic, 18:2), and 9-*cis*,12-*cis*,15-*cis*-octadecatrienoic acid (linolenic, 18:3).

Fats and oils are distinguished by their physical state; fats are solid at ambient temperature, whereas oils are liquid. Some edible triglycerides, such as butter, lard, vegetable oils, shortenings, and margarines, have substantial quantities of both liquid and solid components at ambient temperature. Commercial products may be derived from animal carcasses by rendering, or vegetable sources by pressing or solvent extraction (4).

Composition

Natural fats and oils are composed principally of triglycerides, but other components may be present in minor quantities. These components may have important effects on the nature and quality of the oil or fat.

Free Fatty Acids and Partial Glycerides. After harvest, many crude oil crops contain lipase enzymes that cleave triglycerides into fatty acids and partial glycerides. For example, free fatty acid content of rice bran oil and palm oil can

Table 1. Fatty Acids Found in Naturally Occurring Triglycerides

Fatty acid	CAS Registry Number	Common name	Designation[a]	Principal sources
butanoic	[*107-92-6*]	butyric	4:0	butter
hexanoic	[*142-62-1*]	caproic	6:0	butter
octanoic	[*124-07-2*]	caprylic	8:0	coconut
decanoic	[*334-48-5*]	capric	10:0	coconut
dodecanoic	[*143-07-7*]	lauric	12:0	coconut, palm kernel, butter
tetradecanoic	[*544-63-8*]	myristic	14:0	coconut, palm kernel, butter
hexadecanoic	[*57-10-3*]	palmitic[b]	16:0	palm, cottonseed, butter, animal fat, marine fats
cis-9-hexadecenoic	[*373-49-9*]	palmitoleic	16:1 (9*c*)	butter, animal fats
octadecanoic	[*57-11-4*]	stearic[b]	18:0	butter, animal fats
cis-9-octadecenoic	[*112-80-1*]	oleic[b]	18:1 (9*c*)	olive, tall oil, peanut, canbra[c], animal fats, butter, marine fats
cis,cis-9,12-octadecadienoic	[*60-33-3*]	linoleic[b]	18:2 (9*c*, 12*c*)	safflower, sunflower, corn, soy, cottonseed
cis,cis,cis-9,12,15-octadecatrienoic	[*463-40-1*]	linolenic	18:3 (9*c*, 12*c*, 15*c*)	linseed
cis,cis,cis,cis-6,9,12,15-octadecatetraenoic	[*20290-75-9*]		18:4 (6*c*, 9*c*, 12*c*, 15*c*)	marine fat
cis,trans,trans-9,11,13-octadecatrienoic	[*506-23-0*]	α-eleostearic	18:3 (9*c*, 11*t*, 13*t*)	tung
12-hydroxy-*cis*-9-octadecenoic	[*141-22-0*]	ricinoleic	18:1 (9*c*) 12-OH	castor
cis-9-eicosenoic	[*29204-02-2*]	gadoleic	20:1 (9*c*)	marine fat
cis-11-eicosenoic	[*5561-99-9*]		20:1 (11*c*)	rapeseed
all *cis*-5,8,11,14-eicosatetraenoic	[*506-32-1*]	arachidonic	20:4 (5*c*, 8*c*, 11*c*, 14*c*)	animal, marine fats
all *cis*-8,11,14,17-eicosatetraenoic	[*24880-40-8*]		20:4 (8*c*, 11*c*, 14*c*, 17*c*)	marine fats
all *cis*-5,8,11,14,17-eicosapentaenoic	[*10417-94-4*]		20:5 (5*c*, 8*c*, 11*c*, 14*c*, 17*c*)	marine fats
docosanoic	[*112-85-6*]	behenic	22:0	
cis-11-docosenoic	[*506-36-5*]	cetoleic	22:1 (11*c*)	marine fats
cis-13-docosenoic	[*112-86-7*]	erucic	22:1 (13*c*)	rapeseed
all *cis*-7,10,13,16,19-docosapentaenoic	[*24880-45-3*]		22:5 (7*c*, 10*c*, 13*c*, 16*c*, 19*c*)	marine fats
all *cis*-4,7,10,13,16,19-docosahexaenoic	[*6217-54-5*]		22:6 (4*c*, 7*c*, 10*c*, 13*c*, 16*c*, 19*c*)	marine fats

[a]Number of carbon atoms: number of double bonds (geometric (cis, trans) isomerism).
[b]Constituent of most fats.
[c]Low erucic rapeseed.